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(56) Documents cited
WO 91/10344 A1 WO 90/15070 A1 JP 630060196 A
SE 008404967 A US 5021672 A US 4987312 A
US 4515920 A US 3725111 A

(58) Field of search
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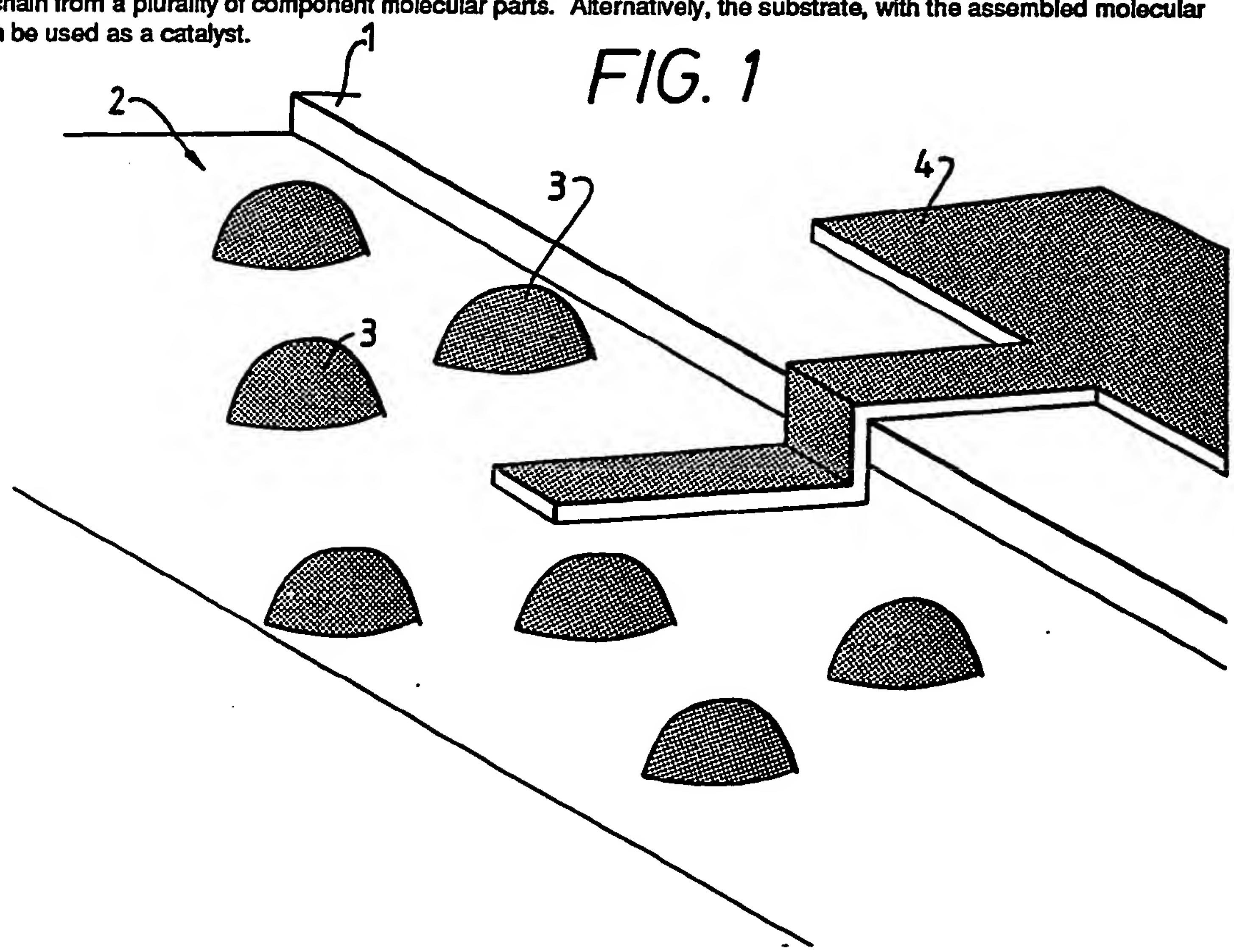
(54) Molecular synthesis

(57) Molecular synthesis is carried out on a substrate (1) provided with a nanofabricated surface structure (2, 3) typically formed by means of a scanning tunneling microscope. The resulting surface structure acts as a molecular template and components parts of a molecular structure are moved to the template e.g. by control potentials applied to surface electrodes (4) formed by electron beam lithography on the substrate. A long molecular chain can be assembled using the substrate to form the chain from a plurality of component molecular parts. Alternatively, the substrate, with the assembled molecular chain, can be used as a catalyst.

FIG. 1



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

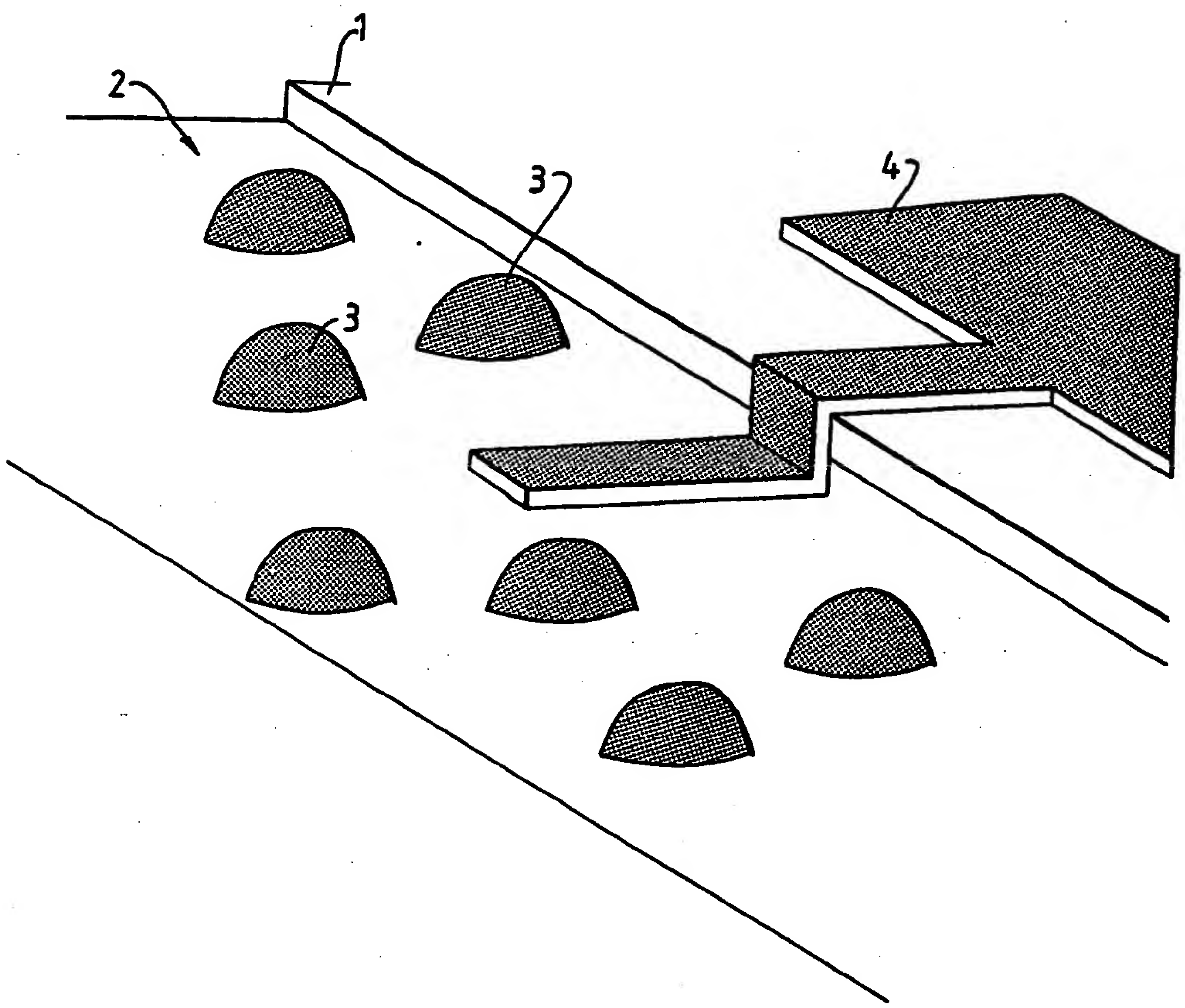
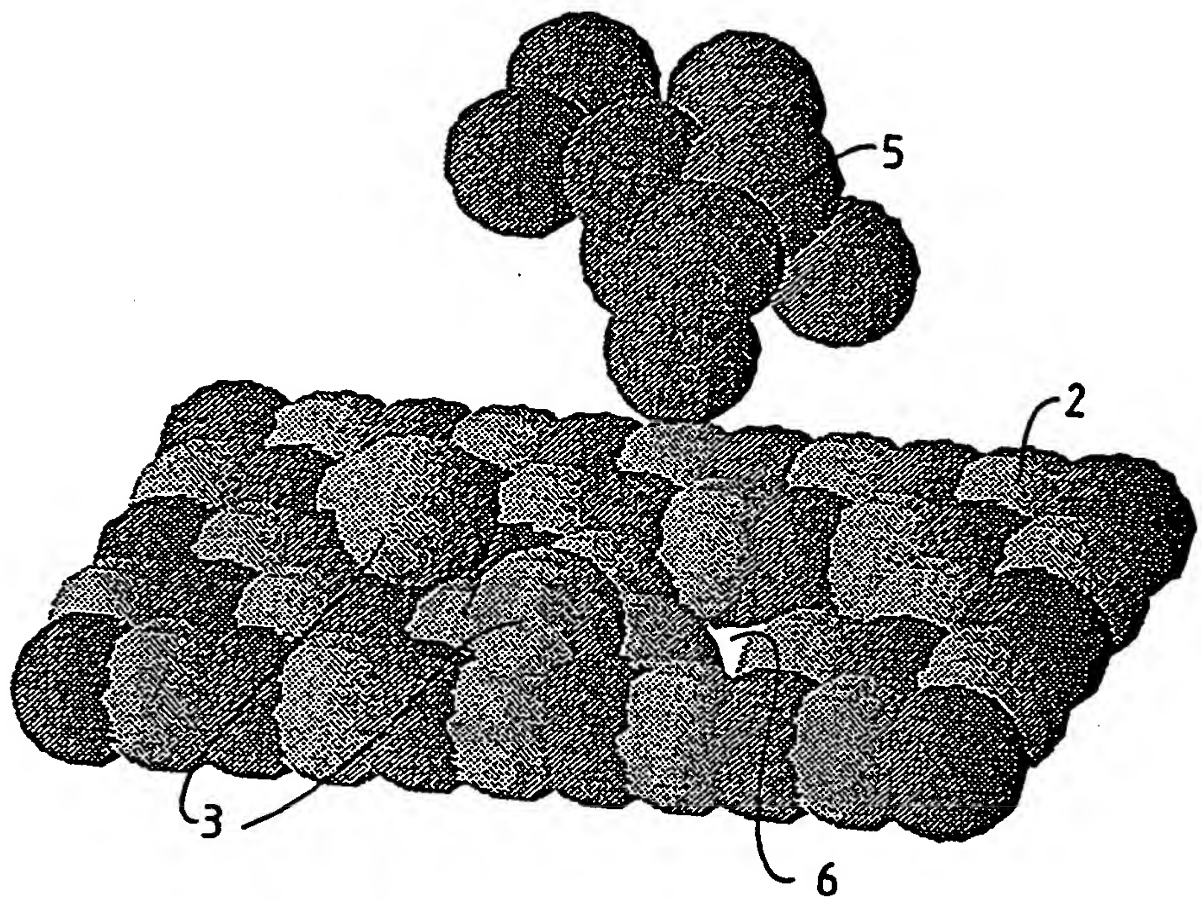


FIG. 2



MOLECULAR SYNTHESIS

DESCRIPTION

This invention relates to molecular synthesis and has particular but not exclusive application to synthesising large organic molecules.

Large organic molecules are of increasing interest for microelectronic applications. In particular, linear conducting molecules are being investigated for use in transistors and other devices and microcircuits. Linear conductors can exhibit semiconductivity, Fröhlich super- conductivity, charge and spin density waves (Peierls transition), and should show other one dimensional transport properties. They are potentially ideal one dimensional conductors, as both electron and phonon transport may be confined to single atomic chains. This is manifested most clearly where there are conjugated (e.g. π-conjugated carbon) bonds along the principal axis, and much weaker (e.g. hydrogen) bonds in perpendicular directions. This case ensures maximum

electron transport localisation to the principal axis, and also maximum phonon transport localisation. It is systems such as this that show Peierls transitions very clearly, and also have been demonstrated exhibiting superconductivity with a critical temperature in the region of 15K. One of the problems with experiments on these systems is that they must be conducted on crystals containing many hundreds of molecules, which are inherently highly defective.

It is an object of the present invention to provide a method by which such long chain molecules can be synthesised. In accordance with the invention, there is provided a method of molecular synthesis comprising providing a substrate with a nanofabricated surface structure that acts as a molecular template for permitting a particular molecular structure to form thereon, and feeding component parts of said molecular structure to the template so as to form said structure thereon.

The invention also includes a substrate for use in the method including said nanofabricated surface structure for use as the molecular template.

The template may be formed by microwriting with a scanning tunneling microscope (STM), or other lithographic device with atomic resolution.

The method may also include moving the molecular structure formed on the template away from the region, and the substrate may include control regions for applying control potentials for moving the molecular component parts to or from the template region. The control regions may be formed by electron beam lithography, or other fine lithography.

The unit cell of a large molecule may be formed, then moved to one side as another unit cell is formed then joined to the first and so on.

Thus, by means of the invention, it is possible to synthesise long chain molecules. The molecules thus formed may be moved from the template so that

successive molecular fabrications can be achieved in the manner of a production line.

Alternatively, component parts of the molecular structure may be at first physisorbed onto the surface (electrostatic van der Waals type bonding) and then be chemisorbed (bonded more strongly to the template). The resulting synthesised molecular structure produces a charge density variation which allows reaction with other molecules which are on the surface or in an ambient medium. This would thus mimic certain types of inorganic enzymes and catalysts.

Additionally, potentials could be applied to the surface in such a way as to enhance the reaction. For example, bonds could be stretched or weakened or broken, permitting reactions which would not otherwise take place.

In order that the invention may be more fully understood an example thereof will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic perspective view of a substrate for use as a template in a method according to the invention; and

Figure 2 is a schematic perspective view of another substrate which has had its surface modified by STM to receive an incoming molecule in a particular orientation.

Referring firstly to Figure 1, this shows a trench formed in a substrate by an STM method. As shown schematically, the lattice structure of the material eg silicon, has been modified by STM writing so as to form a trench 2 which includes a number of atomic "hillocks" 3, constituted by a localised accumulation of atoms. The pattern of hillocks 3 is selected to form a template that will receive component parts of a molecular structure to be synthesised. The structure thus acts as a template for a long chain molecule. It may be desirable to apply electrical biasing to the trench to ensure that the local potential distribution corresponds to the molecule to be synthesised.

An electron beam lithography defined structure 4 is utilised to move component parts of the molecule to be synthesised into the trench. The structure 4 thus may comprise a control electrode to which control potentials are applied to shift the component molecular parts over the surface of the substrate to the trench.

The substrate may be grown, or altered with the atomic resolution lithography, so as to allow the application of potentials.

It will be appreciated that the formation of the trench by STM methods is time-consuming. Thus, the formation of the control electrodes 4 by electron beam lithography greatly facilitates construction of the device since the lower resolution lithography method can be carried out at a much faster rate than STM techniques.

Figure 2 shows schematically a molecule 5 approaching the molecular surface of the trench 2. The molecular hillock 3, formed by STM methods is configured in such

a way that the molecule can only enter the recess 6 in a particular orientation. Thus, by arranging a number of such hillocks 3 and recess 6 along the length of the trench 2, it is possible to assemble component molecular parts such as the molecule 5 in a predetermined orientation along the trench, such that the molecules will bond to one another so as to synthesise a long chain molecule. Additional control electrodes (not shown) formed by electron beam lithography may be used to shift the synthesised molecule away from the trench for further use. Thus, the trench can be used as a tool in a production line process for assembling many molecules of identical molecular configuration. Such long chain molecules may be used e.g. for microcircuit fabrication. For molecules which have a repetitive molecular structure, it may be possible to define a unit cell in the trench so that the electrodes 4, after formation of a first unit part of the molecule, move the molecule along so that a second unit part can be formed thereon etc. in a continuous flow.

The nanofabricated surface structure need not necessarily be a trench; it could be a freestanding bridge or cantilever structure or of other suitable configuration.

In addition to forming molecules for microcircuits, it may be possible to synthesise pharmaceutical compositions, or molecules for other applications.

The surface itself could be used as a catalyst. Thus, the template defined by STM can be used to absorb preferentially molecules in a particular configuration so as to synthesise a particular reaction. In a first, passive system, molecules or atoms are first physisorbed onto the surface of the substrate (electrostatic van der Waals type bonding) and then chemisorbed (bond more strongly to the surface) to produce a charge density variation which allows reaction with certain other species which are on the surface or in an ambient medium. This would mimic certain types of inorganic catalysis.

An active catalytic device could also be produced. This will alter the field distribution with applied potentials in such a way as to enhance a chemical reaction. For example bonds could be stretched or weakened or broken, permitting reactions which would not otherwise take place. Whilst the invention is primarily considered suitable for synthesising organic long chain molecules, it may also be applicable to inorganic molecular synthesis and catalysis.

CLAIMS

1. A method of molecular synthesis comprising providing a substrate with a nanofabricated surface structure that acts as a molecular template for permitting a particular molecular structure to form thereon, and feeding component parts of said molecular structure to the template so as to form said structure thereon.

2. A method according to claim 1 including moving the molecular structure formed on the template away from said nanofabricated surface structure.

3. A method according to claim 1 or 2 including applying control electrical potentials to said component parts during the formation of said molecular structure.

4. A method according to any preceding claim including applying control potentials to the substrate adjacent said nanofabricated surface structure so as to

move component parts of said molecular structure to the template.

5. A method according to any preceding claim including applying control potentials to the substrate to move the molecular structure formed by the template away from said nanofabricated surface structure.

6. A substrate for use in a method according to any preceding claim including a nanofabricated surface structure that acts as a molecular template for permitting a particular molecular structure to form thereon.

7. A substrate according to claim 6 wherein said nanofabricated surface structure includes a region wherein the molecular structure of the substrate has been modified by microwriting with a scanning tunneling microscope to define said template.

8. A substrate according to claim 6 or 7 including control regions for applying control potentials for

moving said molecular component parts to or from the template region.

9. A substrate according to claim 6, 7 or 8 wherein said control regions are formed by electron beam lithography.

10. A method of molecular synthesis substantially as hereinbefore described with reference to the accompanying drawings.

11. A substrate for use in molecular synthesis, substantially as hereinbefore described with reference to the accompanying drawings.

12. Molecular structures formed by a method according to any one of claims 1 to 5.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition K)

(ii) Int Cl (Edition 5) C08F; H01J

Search Examiner

B J BALDOCK

Databases (see over)
(i) UK Patent Office

(ii) ONLINE DATABASES: DERWENT WPI, WPIL

Date of Search

4 NOVEMBER 1991

Documents considered relevant following a search in respect of claims 1 TO 12

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	WO 91/10344 A1 (DU PONT DE NEMOURS)	at least 1,6
X	WO 90/15070 A1 (AFFYMAX TECHN)	at least 1,6
X	US 5021672 (DU PONT DE NEMOURS)	at least 1,6
X	US 4987312 (IBM)	at least 1
X	US 4515920 (ROCKEFELLER)	at least 1,6
X	US 3725111 (HOFFMAN-LA-ROCHE)	at least 1,6
X	SE 008404967 A (MOSBACH)	at least 6
A	JP 630060196 A (NEC CORP) - see WPI Accession No:- 88-115003/17	at least 1

Category	Identity of document and relevant passages	Rele ..t to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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